

## P2.23 A FIELD EXPERIMENT TO STUDY RAIN MICROPHYSICS USING VIDEO DISDROMETERS, PROFILER, AND POLARIMETRIC S- AND X-BAND RADARS

Guifu Zhang<sup>1</sup>, Qing Cao<sup>1</sup>, Ming Xue<sup>1</sup>, Phillip Chilson<sup>1</sup>, Michael Morris<sup>1</sup>, Robert Palmer<sup>1</sup>,  
Jerry Brotzge<sup>1</sup>, Terry Schuur<sup>2</sup>, Edward Brandes<sup>3</sup>, Kyoko Iketa<sup>3</sup>,  
Alexander Ryzhkov<sup>2</sup>, Dusan Zrnica<sup>2</sup>, and Edward Jessup

<sup>1</sup>University of Oklahoma, Norman, OK 73072

<sup>2</sup>National Severe Storms Laboratory, NOAA, Norman, OK 73072

<sup>3</sup>National Center for Atmospheric Research, Boulder, CO 80301

### 1. INTRODUCTION

Understanding and characterizing rain microphysics are important for accurate quantitative precipitation estimation (QPE) and quantitative precipitation forecasts (QPF) (Brandes et al. 2002; Zhang et al. 2001). Recent advancements in disdrometer and radar observation techniques make more in-depth studies in such an area possible. A two-dimensional video disdrometer (2DVD) measures the size, shape, orientation and fall speed of each precipitating particle, yielding detailed information about rain microphysics (Kruger and Krajewski 2002; Schuur et al. 2001). A vertically pointing UHF wind profiler reveals the reflectivity-weighted motion of hydrometeors at various heights. A polarimetric radar provides a large spatial coverage with measurements of reflectivity, differential reflectivity, specific differential phase and cross-correlation coefficient that depend on cloud/precipitation physics (Cao et al., 2007). The 2DVDs, profiler and polarimetric radars are ideal complementary tools for studying rain microphysics and associated storm evolutions.

In collaboration with the NOAA National Severe Storms Laboratory (NSSL), the National Center for Atmospheric Research (NCAR), and the NSF ERC for Collaborative Adaptive Sensing of the Atmosphere (CASA), the University of Oklahoma (OU) organized a field experiment in central Oklahoma during the spring storm season of 2007. Disdrometer and radar datasets were collected and processed. The experiment configuration and preliminary results are presented in this paper.

### 2. EXPERIMENT DESCRIPTION

During the experiment period, NSSL ran an S-band polarimetric weather radar (KOUN), a prototype for the polarization upgrade of the national WSR-88D network. CASA was operating its Integrative Project One (IP1) testbed in southwest Oklahoma that is composed of four X-band polarimetric radars. Figure 1 shows the disdrometer and radar sites. The two disdrometer sites were chosen such that the data can be processed jointly with dual/tri-Doppler analysis and polarimetric radar measurements.

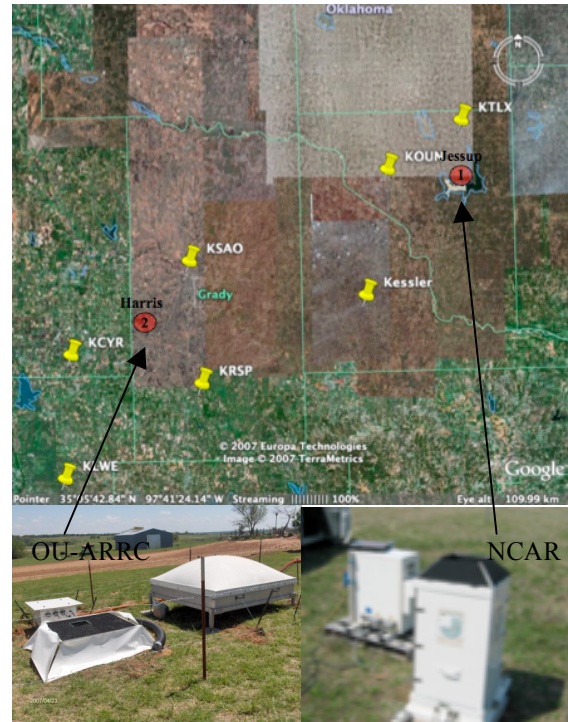


Figure 1: Disdrometer sites and polarimetric radar locations for the 2007 field experiment.

The two disdrometers used in this experiment are the high-profile 2DVD of NCAR and the low-profile (updated version) 2DVD of OU's Atmospheric Radar Research Center (ARRC). Both have the same characteristics and similar accuracy. The OU disdrometer had been placed at the Kessler farm, its primary site, since its arrival in 2005. During the experiment, it was moved to Cement, Oklahoma, and deployed on the land of Tommy Harris (34°56'19.5" N, 98°4'31.08" W) from 24 April to 9 July 2007, together with a UHF boundary layer wind profiler. The site is roughly at the center of the triangle formed by three CASA IP1 radars (KSAO, KCYR and KRSP) located at Chickasha, Cyril, and Rush Springs, respectively, and hence has triple Doppler radar coverage. The NCAR disdrometer was brought to Norman, Oklahoma and deployed near Lake Thunderbird, on the land of Edward Jessup (35°13'50.68" N, 97°16'34.52" W), a site under a dual-Doppler lobe formed by the KOUN polarimetric radar and the Oklahoma City WSR-88D radar (KTLX). The deployment of the NCAR disdrometer lasted from April 3<sup>rd</sup> to August 31<sup>st</sup>. The two disdrometer sites are at short (20 km) and medium (76 km) ranges from KOUN radar, al-

Corresponding author address: Guifu Zhang,  
School of Meteorology, University of Oklahoma,  
Norman, OK 73072; guzhang1@ou.edu

lowing disdrometer-radar comparisons for different resolution volumes.

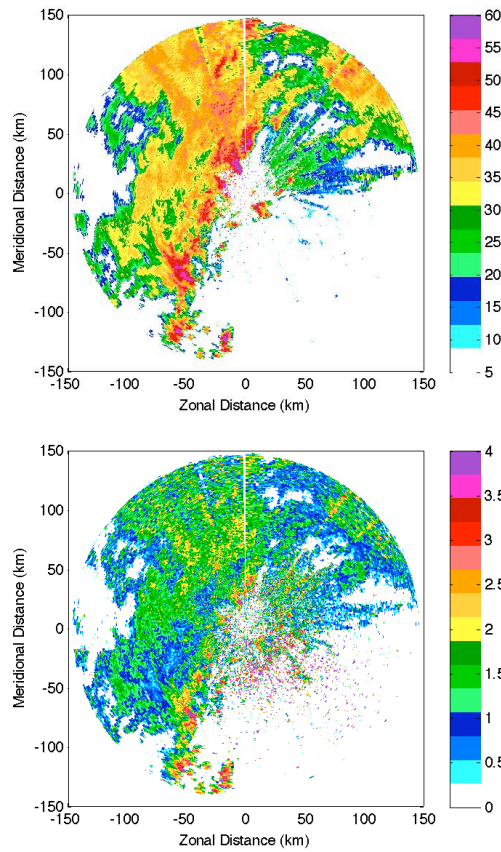


Figure 2: S-band polarimetric KOUN radar images of reflectivity and differential reflectivity measured at 1304 UTC on 8 May 2007.

### 3. DATA SET AND ANALYSIS

KOUN radar collected data for about 90% of the rain events. The CASA radars also operated in their own field experiment mode from 9 April to 10 June 2007 (Chandrasekar et al. 2008). The wind profiler functioned for a few rain events. A variety of storms occurred over the disdrometer sites (see, e.g., Brewster et al. 2008). Figure 2 shows an example of S-band radar reflectivity ( $Z_H$ ) and differential reflectivity ( $Z_{DR}$ ) measured by KOUN for a rain event at 1304 UTC 8 May 2007. This case is also being studied from several perspectives (Brotzge et al. 2008; Gao et al. 2008; Schenkman et al. 2008).

The raindrop size distribution (DSD) data recorded by the two 2DVDs is summarized in Table 1. OU disdrometer collected 403.5 mm accumulated rain and NCAR disdrometer received 340.4 mm rain total. The NCAR disdrometer accumulated less precipitation even though it was deployed longer because it was struck by lightning during several midnight thunderstorms in June. The total rain accumulation received by a rain gauge on the roof of the Jessup house was 720.6 mm for the same period.

The datasets are being processed to characterize rain

microphysics and microphysical processes, including

Table 1.: Rain events and amounts collected by 2DVDs

Date	Site 1: NCAR 2DVD Lake Thunderbird		Site2:OU 2DVD Cement	
	main period (UTC)	Rain (mm)	main period, (UTC)	Rain, (mm)
4/24/07		N/A	1530-1830	6.65
5/1/07	1810-2020	20.23	600-2100	13.64
5/2/07	200-530	6.96		N/A
5/3/07	2110-2240	8.08		N/A
5/7/07	745-805	6.43	600-1300	59.79
5/8/07	735-940, 1330-1600	20.18	730-1430	21.48
5/9/07	355-505	2.49	200-400	14.28
5/10/07	730-1200, 1940-2400	23.88	520-1330, 2230-2400	21.89
5/11/07	2140-2200	2.52		N/A
5/15/07		N/A	1230-1730	4.24
5/24/07	1300-1900	25.99	1240-1600	26.73
5/26/07	500-1130	8.31	1840-1940	0.85
5/27/07	400-1930	21.35		N/A
5/28/07	1640-2400	1.86		N/A
5/30/07		N/A	1010-1130	12.33
6/1/07	2210-2400	3.09	1920-2210	18.29
6/2/07	0000-100	11.9		N/A
6/8/07		N/A	715-800	4.43
6/10/07		N/A	2300-2400	13.51
6/14/07	750-1310	13.38	650-1020	20.23
6/15/07		N/A	200-500, 750-1030	3.79
6/16/07		N/A	1820-1920	2.16
6/17/07		N/A	700-900, 1245-1630	15.29
6/18/07	430-630, 1330-1430	3.5	1100-1130	1.78
6/20/07	510-900	13.02	400-600	22.76
6/21/07	2000-2400	30.65		N/A
6/24/07		N/A	100-700	10.12
6/25/07	2000-2400	9.27	1745-1815, 2040-2150	6.11
6/26/07	1140-2300	18.37	700-1600	53.24
6/27/07	500-1820, 2300-2400	1.74	920-1430	7.61
6/28/07	1030-2400	6.50	930-1500, 1900-2330	26.86
6/29/07	1230-2400	15.48	0000-1800	10.63
7/2/07		N/A	1410-1540	3.12
7/5/07	2320-2350	2.09	650-720, 2300-2400	1.72
7/9/07	2350-2400	4.83		N/A
7/10/07	0000-0050, 430-805	10.0		N/A
7/12/07	1350-1630	7.17		N/A
7/13/07	900-1610	31.39		N/A
7/23/07	1600-1830	4.59		N/A
7/30/07	2005-2105	5.20		N/A

evaporation and accretion using a method similar to that in Zhang et al. (2006). Also calculated from rain DSDs are the S- and X-band polarimetric radar variables:  $Z_H$  and  $Z_{DR}$ , where radar reflectivity in hori-

zonal/vertical polarization is the integral of the DSD weighted radar cross-sections calculated using the T-matrix method. The DSD-based  $Z_H$  and  $Z_{DR}$  results are compared with the radar measurements made at an elevation of  $0.5^\circ$  for KOUN and  $1.0^\circ$  for KSAO in Fig. 3. The radar measurements have been averaged over five range gates to reduce sampling error.

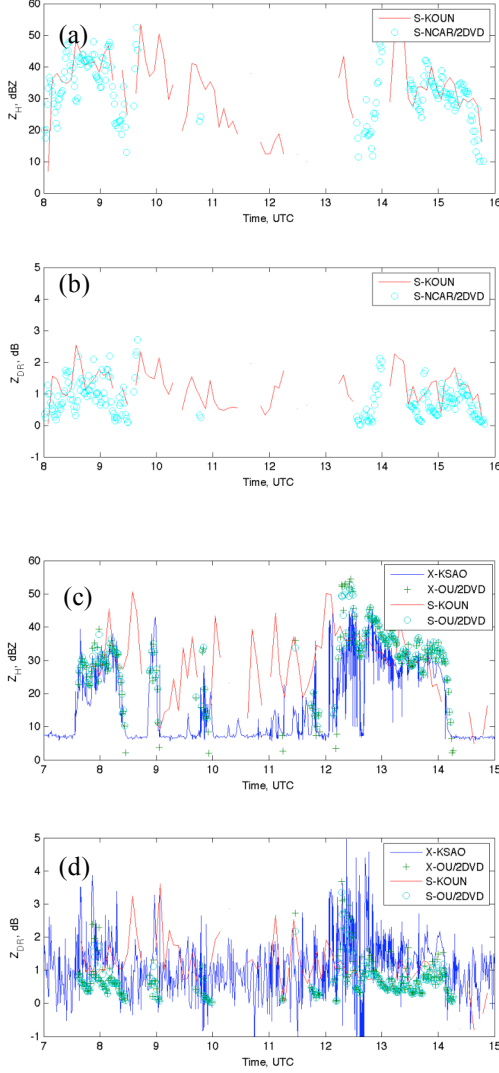


Figure 3: Comparisons of S- and X-band polarimetric variables of reflectivity and differential reflectivity between radar and disdrometer measurements for the 05/08/2007 rain event.

Figure 3a and 3b are comparisons of the S-band radar measurements with those of the disdrometer at site 1, which is 20.3 km from KOUN. The results generally agree well except for the middle portion with little rain. Figure 3c and 3d show the radar-disdrometer comparison for site 2, which is under the coverage of both KOUN and CASA radars. The X-band KSAO measurements follow the trend of disdrometer results better than KOUN measurements, which is, we believe, because the KSAO is closer at the 16.8 km range versus 75.8 km for KOUN, yielding a better angular resolution in addition to its finer range resolu-

tion. However, the KSAO measurements contain more noise than the KOUN results. Also, X-band  $Z_{DR}$  measurements by KSAO appear to be larger than the disdrometer results.

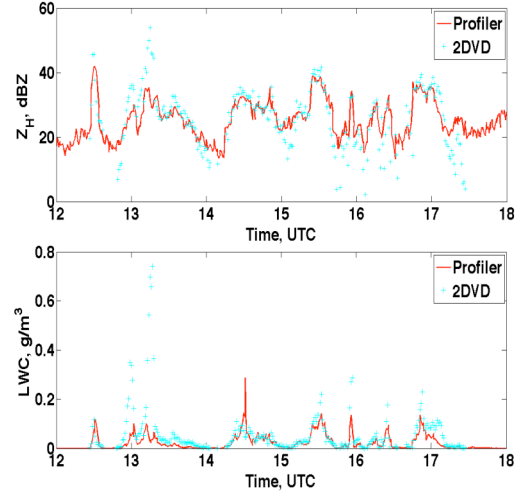


Figure 4: Comparisons of reflectivity factor and rainwater content between the profiler and disdrometer measurements for the 05/15/2007 rain event.

The profiler functioned for a few rain cases on May 15, May 24 and June 8, 2007. Figure 4 shows the comparison of reflectivity factor (upper) and rainwater content (lower) for the May 15 rain event. Overall, the profiler and disdrometer results follow each other closely. However, the profiler did underestimate the reflectivity and water content during the convective updraft period (1300-1330 UTC). Further analysis of the data comparisons needs to be made.

The potential of polarimetric radars and profilers in microphysical parameterization is being studied through rain DSD retrieval and will be reported in the future. The relationship between precipitation microphysics and storm evolution is being studied using the dual- and triple-Doppler radar data.

#### 4. SUMMARY AND DISCUSSIONS

In this paper, we described a field experiment to study precipitation microphysics. The experiment configuration and dataset are illustrated. Disdrometer data are processed to calculate polarimetric radar variables at S- and X-band. Preliminary comparisons with KOUN and CASA radar measurements are performed. It is shown that the S-band radar and disdrometer results agree well at the Lake Thunderbird site. At site 2, however, X-band radar measurements follow the general trend of disdrometer results better than the S-band radar, although the X-band measurements contain much more noise.

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